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16. Abstract

This Annotated Bibliography contains 29 references used in preparation for the Federal Highway Administration sponsored project "Evaluation of Control Strategies and Demonstration of Bus Preemption of Traffic Signals in New Jersey".

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AN ANNOTATED BIBLIOGRAPHY ON BUS PREEMPTION OF TRAFFIC SIGNALS

A literature search was conducted as part of the proposal for this project to determine the state of the art concerning bus signal preemption. As a result, an up-to-date annotated bibliography has been compiled.

Each annotation includes a short abstract or summary in which certain specific terms are used. Specific terms used are as follows:

Measures of Effectiveness (MOE) - includes delay measures, load factor calculations, peak hour factor calculations

Field Data - report includes data taken at a field installation

Planned Systems - report contains information for a preemption system for which no data has been published, or the system is being proposed

Control Strategy - methods by which the preemption is incorporated into signal timing

Turn Priority - preemption system for intersection where buses cross an opposing flow

Computer Control - control strategy by computer

Detection Equipment - hardware involved which informs controller of the presence of a bus

Implemented System - preemptive system described in reference has been installed in the field

Relco - preemption control equipment manufactured by Radio-Emergency-Light Company, Erie, Pennsylvania

Opticom - preemption control equipment manufactured by 3M Company, Minneapolis, Minnesota

Rad-O-Lite - preemption control equipment manufactured by

Rad-O-Lite, Philadelphia, Pennsylvania

1) Advanced Control Technology in Urban Traffic Control System, Vol. 1A: Bus Priority System Description, Sperry Rand Corporation, March, 1970, (FHWA - 70, 81-1)

A Bus Priority System as part of the UTCS to be implemented in Washington, DC was described in detail. A cross street queue length threshold, which, when exceeded, denied priority was to be included in the BPS algorithm. Control strategies, bus detectors, and measures of effectiveness are explained. The system was specifically designed around the Washington, DC UTCS system.

2) "Bus Can Call for Green Light," Better Roads, Vol. 44, No. 8, August, 1974, pp. 26-27

A brief description of the OPTICOM system as used on N.W. 7th Avenue in Miami, Florida is given. Signal strategy is either to delay or advance green, and then return to regular cycle. No results are given.

3) Bus Demonstration Project, Summary Report No. 1, Bus Detection, Bus Priorities at Traffic Control Signals, Department of the Environment, U.K., 1972 (Estimated)

Priority was given to buses making right turns in Derby, England. Green time was either advanced or extended depending on arrival time of bus. On the following cycle, phases that were penalized were given additional time as compensation. Traffic on two phases not given priority experienced three or four seconds additional delay. Bus travel times through the intersection were reduced as much as 22 seconds.

4) Bus Priority System - Supplement to the UTCS-1 Program Manual, Working Paper - 8662, MITRE Corporation, February, 1972

Additional input cards necessary to modify original version of the UTCS-1 program to incorporate the capability of simulating control systems that give buses preferential treatment at traffic signals are described.

Also, tables to aid in "trouble shooting" and a technique to reduce storage requirements is given. Changes made in the model after February 4, 1972 are not shown.

5) "A Bus Priority System for Traffic Signals," Kent State University, UMTA Project Ohio MTO-4, 1974

Driver activated preemption system installed in Kent, Ohio. Three successive intersections were interconnected, actuated, and equipped for preemption. Preemption was achieved using radio transmitters and receivers actuated by the bus driver. Average speed of buses increased 10 percent as a result of all improvements.

6) Erikson, A. R., A Central Area Transit Simulation Model, Transportation Program, System-Design Department, College of Applied Science and Engineering, University of Wisconsin, Milwaukee, Wisconsin, 1972 (Estimated)

The model simulates all operations of buses including passenger discharge and pick-up and delays at traffic signals. The model is "event advanced" stochastically assigning values to bus descriptive parameters. The author uses the model to simulate various bus priority techniques; among them, bus signal preemption. A preemption system, according to the model, will result in a 15 percent reduction in delay, assuming buses do not wait at red lights. One important disadvantage of the model is that it only simulates bus travel.

7) Erikson, A. R., Norconsult, A. S., and Beimborn, E. A., Effectiveness of Alternative Downtown Area Bus Distribution Systems, HRR 459, pp. 29-39, 1973

Various types of bus operations, including preemption, are simulated in a stochastic model which simulates bus

movements. Other kinds of vehicles are not considered in the model. In the simulation of an urban bus system, bus travel time was reduced by 15 percent.

8) Evans, H. K., and Skiles, G. W., "Improving Public Transit Through Bus Preemption of Traffic Signals," Traffic Quarterly, Vol. 24, No. 4, October, 1970, pp. 531-543

In an experiment in Los Angeles, California, an observer manually actuated signals at two adjacent intersections, either advancing or extending the green, in accordance with a minimum side street green. Stop delays were observed and recorded for both cross street and through traffic. Stop delay for buses was only compared before and after on the preferred approach. There were increased delays on cross streets of 51 percent and 24 percent, but overall intersection delay was reduced. Person delay was also considered but results were not conclusive.

9) Ferlis, R. A., Worall, R. D., Experimental Applications of the UTCS-1 Network Simulation Model, Peat, Marwick, Mitchell & Co., Paper prepared for the Transportation Research Board, January, 1975

This is basically a summary of Report No. FHWA-RD-73-83 (referenced in this bibliography). It contains a brief description of simulated SIGOP and TRANSYT signal settings which showed TRANSYT to produce lower delays and higher speeds under all traffic conditions.

10) Preferential Treatment for High Occupancy Vehicles, Federal Highway Administration Report, April, 1974

Various strategies for bus priorities are discussed briefly. This includes a one page discussion of the UTCS/BPS system in Washington, DC.

11) The I-95/N.W. 7th Avenue Bus/Carpool Systems, Florida Department of Transportation, 1972 (Estimated)

Part I of project will measure reduction in travel time as a function of: a) preemption, b) reserved bus lane and preemption, c) reserved bus lane and signal progression and preemption, d) reserved bus lane and centrally coordinated progressive preemption. Demonstrations on Part I will be conducted on N.W. 7th Avenue. Also to be measured are reduction in schedule variability, increase in transit patronage, and increase in passenger-carrying capability of street. Effect on operational characteristics is estimated. Bus priority system control equipment performance will be evaluated.

12) Specifications for Transit Priority Traffic Control Equipment, State of Florida Department of Transportation, March, 1973

These are the original specifications for the Florida I-95, N.W. 7th Avenue Corridor Project in Dade County. These specifications refer specifically to the bus signal preemption equipment used in that project. Specifications are broken into three categories; those for on-board vehicle equipment, those for roadside detectors, and those for phase selectors.

13) Huddart, K. W., "Giving Buses Priority at Signalized Junctions," Bus Priority, Proceedings of a Symposium Held at TRRL, 1972 TRRL Report LR 570, 1973, pp. 120-124

This article discusses strategies to be used in algorithms for bus preemption. It briefly discusses preemption efforts in Leicester, England, Washington, DC and Los Angeles. Radio and optical methods of preemption are also briefly discussed. In conclusion, the author

expresses the opinion that "equipment exists or could be readily designed" for bus signal priority operations.

14) Levinson, H. S, Hoey, W. F., Sanders, D. B., and Wynn, F. H., "Appendix C, Case Studies of Arterial Bus Priority Treatments," Bus Use of Highways, NCHRP 143, Highway Research Board, 1973

"Kent Bus-Actuated Traffic Signals," p. 246

Bus travel times were reduced by about 10 percent as a result of coordination, actuation and bus preemption of three signals in a demonstration project in Kent, Ohio. Driver actuated preemption extended green up to 7 seconds or advanced through green according to a minimum side street green. Side street delays were not significantly increased over the uncoordinated, unactuated signal system. This system worked for buses in both opposing directions, with average headways of four minutes in each direction.

"Leicester Bus Priority at a Traffic Signal," pp. 290-291

Priority was given to buses making right hand turns in Leicester, England. At one intersection, automatic devices on the bus actuated detector loops in the highway, which were placed approximately 100 feet from the intersection. Subsequent signal phases were given extended green times. Travel times decreased, while consistency and regularity increased for buses. Detector loops for preemption were found to be located too close to the intersection, allowing buses queuing upstream from the intersection to go undetected.

15) Ludwick, J. S., Jr., Simulation of an Unconditional Preemption Bus Priority System, The MITRE Corporation, MTP-400, December, 1974

Bus routes in Washington, DC were simulated using a version of UTCS-1 modified to use a type of unconditional preemption bus priority. Effects of bus headways and bus stop locations on bus and other vehicle traffic were tested. It was found that far side bus stops produced the least adverse effects on preempted traffic. It was found that unconditional preemption produced an improvement of between 15 to 20 percent improvement in bus network travel time.

16) Marketing Handout for the RELCO Rapid Transit Program, Radio-Emergency-Light Co., 3427 Sterrettania Road, Erie, PA, 1975 (estimated)

The literature briefly describes RELCO as a radio operated preemption system involving an on-board bus transmitter, and an intersection preempter operated by the transmitter.

17) Muzyka, A., Bus Priority Strategies and Traffic Simulation; Working Paper, U.S. Department of Transportation, Transportation Systems Center, August 5, 1974

This paper describes the Simulation of Corridor Traffic (SCOT) model. It also describes its use in simulating exclusive bus lane and contraflow bus lane operation. The model is capable, according to this paper, of simulating bus preemption strategies. A brief description of the model logic is given in this paper, although the majority of space is given to describing the exclusive and contraflow bus lane and results of their simulation.

18) Opticom - Green Signals all the Way, Pamphlet, Traffic Control Products Division, 3M Company, 1975 (estimated)

The pamphlet briefly describes the OPTICOM Preemption System. Three components comprise the system; an emitter on board the bus which uses a light beam to activate a detector mounted on the traffic signal which in turn operates a phase selector mounted in the signal control cabinet.

19) Urban Corridor Demonstration Program, Transit Improvement Program Evaluation, "Chapter II, Current Evaluation, Opticom System," prepared for Falls of Ohio Metropolitan Council of Governments, by Schimpeler-Corradino Associates, 1429 South Third Street, Louisville, Kentucky, May, 1973, pp. 67-76

The "Opticom System" used in Louisville, Kentucky is briefly described. Express buses were 9 percent to 12 percent faster in the morning with Opticom than without and 16 to 19 percent facter in the afternoon. Through eight preemption equipped intersections, load factors for priority approaches decreased with Opticom. It was felt that this was caused by non-responsive malfunctioning actuation equipment which prior to OPTICOM yielded incorrect signal splits. Side-street load factors were not considered.

20) Priority Techniques for High Occupancy Vehicles, Working Draft, Technology Sharing, State-of-the-Art Overview, sponsored by U.S. Department of Transportation, November, 1975

The Washington, DC system where some 500 buses can be granted preemption at up to 111 intersections is briefly described. A chart indicates that preemption is generally applicable to local bus service. One to

five years is required for planning, 5-10 buses/hr. peak one-way is recommended, and passenger volumes should range from 400-600, one-way, peak. Also, selected characteristics of preemption systems in Dallas, Texas; Kent, Ohio; Louisville, Kentucky; Miami, Florida; and Washington, DC are summarized in a chart.

21) Radelat, G., Simulation of Urban Bus Operation on Signalized Arterials, FHWA, Report No. FHWA-RD-74-6, December 1973

This study developed a simulation model that represents urban bus operation on signalized arterial streets. Relationships involving the time required to load and unload a certain number of passengers, bus speed, and acceleration characteristics were investigated. Traffic is simulated on the model by groups of vehicles that are processed at constant time intervals. Buses are represented individually and processed only when significant events occur. One important disadvantage of the model is that it does not consider traffic other than buses.

22) RAD-O-LITE, Electronic Emergency Traffic Control Systems, Pamphlet, RAD-O-LITE of Philadelphia, Inc., 3200 N. 17th Street, Philadelphia, PA, 1975 (estimated)

The pamphlet describes the RAD-O-LITE preemption system which uses a "low VHF" radio transmission to activate the preemption equipment. Additional equipment includes a radio receiver and a signal preemptor. Range on the bus mounted transmitter is adjustable and preemption is by direction.

23) Richbell, L. E. and Van Averbeke, B. A., "Bus Priorities at Traffic Signals," Traffic Engineering and Control, Vol. 14, No. 2, June 1972, pp. 70-75

Priority was given to buses making right hand turns at a single intersection in Leicester, England. Transponders mounted on buses were activated by loop transmitters in the pavement. A receiver within the perimeter of the loop received the signal from the transponder. Priority was awarded by reducing green times on the other two phases of the three phase signal. These phases were compensated on subsequent cycles. The entire signal algorithm was accomplished with a single controller located at the intersection. Although only a small reduction in bus travel time was noticed, consistency of travel time was greatly increased.

24) Urban Traffic Control and Bus Priority System, Prepared for FHWA by Sperry Systems Management Division, Sperry Rand Corporation, Great Neck, NY

Vol. I: Design and Installation, Report No. FHWA-RD-73-9, December, 1972

Volume I presents a comprehensive review of the system design, studies, analyses, traffic surveys, geometric surveys, and trade-off studies which were conducted in conjunction with the UTCS/BPS program. These studies resulted in the selection of system components and parameters which comprise the first-generation UTCS/BPS centralized computer-based traffic control system. The results and conclusions presented highlight

to the advantages and disadvantages of the various components and parameters considered. The basis for selection for the UTCS/BPS is indicated in each case. This report serves as a guide for configurations and specifications of a traffic control system when on-street design considerations affecting a specific application are taken into account.

An Urban Traffic Control and Bus Priority System has been implemented by the Sperry Systems Management Division in the District of Columbia under FHWA contract No. FH-11-7605, "Advanced Control Technology in Urban Traffic Control Systems" - Installation. The system includes on-street surveillance and control elements and a central office data processing facility.

Vol. II: Operator's Manual

Volume II describes the system elements and the operator's functions for this system.

Vol. III: Maintenance Manual

Volume III describes the procedures required to maintain and adjust the system.

25) Urban Traffic Control and Bus Priority System Software Manual, Vol. I: Functional Description and Flow Charts, Report No. FHWA-RD-73-19, and Vol. II: Variable Definitions, Algorithm and Off Line Software Descriptions, Report No. FHWA-RD-73-20, prepared for FHWA by Sperry Systems Management Division, Sperry Rand Corporation, Great Neck, NY, December, 1972

This manual describes the software for the Urban Traffic Control and Bus Priority System. Volume I contains

Section 1, Introduction and Section 2, Programming Specifications, while Volume II contains Section 3, Glossary and Section 4, Appendices.

26) Tarnoff, P. J., "The Results of FHWA Urban Traffic Control Research: An Interim Report," Traffic Engineering, Vol. 45, No. 4, April, 1975, pp. 27-35

Bus priority system control strategies have undergone an extensive analysis using both simulation studies and full-scale evaluation with the Urban Traffic Control/Bus Priority System equipment in Washington, DC. A BPS algorithm designed to minimize person delay was abandoned. A revised algorithm reduced bus delays from 10 to 30 percent in most cases. Overall, bus travel times through the network were not affected. Non-instrumented buses had increases in delay from 5 to 15 percent.

27) Tarnoff, P. J., Data Errors in Urban Traffic Control Systems, Federal Highway Administration Report, January, 1975

This paper discussed the presence of data errors in the Urban Traffic Control System. Methods of avoiding or minimizing errors are discussed on a system basis. The point is made that any UTCS system will have errors but that an effort should be made in the system design to minimize these errors.

28) Wisepart, I. S. and Meiselbach, C., Feasibility Study of Express Vehicle Traffic Signal System, Airborne Instruments Laboratory, Report No. 2315-1, March, 1967

A method of calculating crossroad minimum green is presented in Appendix A. A preemption logic is discussed which may either delay or advance green on the

preferred approach. A detection system is proposed which is based on an interrogator located in the vicinity of the signal and a transponder located on the bus. The transponder is activated by an infrared beam located at the signal which then signals an interragator. Preemption in a progressive system is discussed. When simulated by time space diagrams, three arterials showed no appreciable delay to cross-road traffic.

29) Worrall, R. D., Lieberman, E. and Ferlis, R. A., Network Flow Simulation for Urban Traffic Control System, Phase II, Peat, Marwick, Mitchell & Co., Report Nos. FHWA-RD-83 through FHWA-RD-87, March, 1974

Vol. I: Technical Report

The report summarizes Phase II of the development, testing, and application of the UTCS-1 model. It includes separate sections dealing with:

1. Revision and expansion of UTCS-1 model
2. Expanded calibration inputs
3. Validation of Phase II model
4. Sensitivity tests
5. Initial application of model in UTCS program
6. Additional demonstration tests

Vol. II: Program Documentation for UTCS-1 Network Simulation Model, Part I

Vol. III, Part II

This manual contains detailed program documentation for the expanded version of the UTCS-1 Network Simulation Model, dated May 1, 1973. The first section gives a

brief description of each of the 60 routines making up the model. The second section covers program documentation for each routine, including the program abstract; flow charts; input, operational and output specifications; definition of error handling techniques; and supplementary programming notes. The final section documents the "COMMON" storage arrays and scalar descriptions used by the model.

Vol. IV: User's Manual for UTCS-1 Network Simulation Model

This document contains a general users' guide for the revised version of the "UTCS-1" Network Simulation Model. It is written primarily for use by computer systems and research personnel. The guide includes six major sections, covering: (1) description of revised "UTCS-1" model; (2) input data requirements and procedures for input coding; (3) interpretation of model outputs; (4) detailed operating instructions; (5) error messages; and (6) an illustrative case study.

Vol. V: Applications Manual for UTCS-1 Network Simulation Model

The manual summarizes the potential applications which may be made of the revised UTCS-1 Network Simulation Model by the practicing traffic engineer. It is divided into separate sections covering:

1. A simple description of the model
2. Guidelines for model application
3. Summary of potential applications
4. Selected demonstrations
5. Estimated manpower and resource requirements

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